OLLSCOIL NA GAILLIMHE
UNIVERSITY OF GALWAY

Semester 2 Examinations 2022 / 2023

Course Instance Code(s)	4BCT, 3BP, 4BP, 4BS, 1OA
Exam(s)	BSc in Computer Science & Information Technology BE in Electronic & Computer Engineering, BSc General
Module Code(s)	CT414
Module(s)	Distributed Systems
Paper No.	1
External Examiner(s)	Dr. R. Trestian
Internal Examiner(s)	Prof. M. Madden *Dr. D. Chambers
Instructions:	Answer any 4 questions. All questions carry equal marks.
Duration	2 hours
No. of Pages	4
Department(s)	School of Computer Science
Course Co-ordinator(s)	Dr Colm O'Riordan

Requirements:

Release in Exam Venue	Yes	X	No	
MCQ Answersheet	Yes		No	X
Handout	None			
Statistical / Log Tables	None			
Cambridge Tables	None			
Graph Paper	None			
Log Graph Paper	None			
Other Materials	None			
Graphic material in colour	Yes		No	X

1. Assume that you have been contracted to implement a Distributed Banking System that consists of a server and some Automated Teller Machine (ATM) clients. The server manages all users' account information. A customer can invoke operations at an ATM that are then accessed, and implemented, on a server using Java RMI. Full implementation classes are not required for the server based remote objects but the answer should include the following:

   a: Write a Java interface called *BankServer* that provides methods for user login / authentication, deposit and withdrawal of funds, balance lookup and downloading a *Statement*. The user authentication will be based on using a unique session ID that acts as an authentication token that must be passed to the other methods. 7 MARKS

   b: Write a Java interface called *Statement* that provide methods for the retrieval of the transactions done on a particular bank account over a specified time period. Each individual transaction should be returned in a separate *Transaction* class that encapsulates details about each transaction. Include the source code for the *Transaction* class in your answer. 7 MARKS

   c: Provide the mainline server code required to fully initialise the server and register an instance of the *BankServer* implementation class in the RMI Registry. You do not need to implement the BankServer implementation class; you can assume that this has been provided to you in a class called *BankServerImpl*. 5 MARKS

   d: Provide a simple command line client program that will interact with the server as follows: (i) Login to the server. (ii) Deposit €100 to an account. (iii) Print the balance of an account. (iv) Download a Statement object for an account and print out the associated transactions. 6 MARKS

2.a: Outline the main differences between a *two-tier* and a *three-tier* Client-Server architecture. When would you recommend using a *three-tier* architecture? 5 MARKS

b: Web services represent an evolution and convergence of a number of important areas of technology and business. Describe these technology areas and explain how Web Services builds on previous capabilities. Include in your explanation an overview of the main enabling technologies used to provide Web Services. 10 MARKS

c: You have been asked to develop a commercial online bookstore using J2EE-based technologies. The bookstore architecture and design should be able to support different types of client browsers and should use a three-tier application model i.e. a client tier to support different clients, a middle tier that implements the application business logic and an information tier to persist the application state. Based on these requirements, describe the top-level application architecture. Identify the EJB types that will be used and explain the role each of these plays in the overall system architecture. 10 MARKS

3.a: What is *message oriented middleware* and what types of messaging models are available in the Java Messaging Service? 5 MARKS

b: You are required to design an application that allows programmers to submit votes for their favourite programming language. Describe a suitable architecture and design for a distributed application that uses the Java Messaging Service (JMS) to submit these votes as messages to a queue. Another related application should similarly use JMS to consume these messages from the queue and tally votes. Full Java source code is not required but your answer should provide a full description of how the JMS could be used within the application. Also describe how the application might use the Java Naming and Directory Interface (JNDI) as part of this solution. 10 MARKS

c: Assume that you have been contracted by a large multinational company to develop an enterprise class client / server application that may be accessed by a large number of clients concurrently. You will therefore need to employ some form of load balancing in the design of the application. What type of load balancing systems would you recommend? In this context, include both low level load balancing algorithms and high level load balancing mechanisms such as round-robin DNS and IP Anycast using BGP. Provide some real world examples of systems or services that use DNS and IP Anycast. 10 MARKS

4 a: Explain the role of the Proxmox Virtualisation Environment. In this context, what is the difference between a Virtual Machine and a Container and which of these is faster to migrate to a different host on a Proxmox cluster? 6 MARKS

b: How is it possible to run Virtual Machines at near native speed using Kernel-based Virtual Machine (KVM) infrastructure? 4 MARKS

c: What is the purpose of the Ceph storage platform and what advantages does it have over traditional RAID based storage? Describe the high level architecture and the main components of the Ceph storage platform. Include in this description details about the following items: Ceph Network, Object Storage Devices and Ceph Pools. 8 MARKS

d: What are the advantages of grouping physical servers into a cluster? How does a Proxmox cluster implement High Availability and what might cause a Virtual Machine migration to fail? 7 MARKS

5.a: What is unique about Node.js when compared to other server technologies like e.g. the Apache web server? How can a Node.js application efficiently handle reading and writing very large files e.g. where it is trying to make a copy of a file? 4 MARKS

b: In the context of implementing a web server type application in Node.js what are the advantages of using the **Express** framework? Write the Node.js code to implement a simple web server, using the Express framework, that responds with a simple text message when the URI /**main** is invoked. 7 MARKS

c: Explain how using the Apache Hadoop Distributed File System and its related facilities might help in solving the storage and analysis requirements of an internet search engine company that collects a lot of very large data sets. Discuss the advantages of this approach over using traditional relational database systems for this type of data. 7 MARKS

d: Describe the architecture for a MapReduce application that could be used to index a large number of text files by the individual words present in each file. Full source code for the application is not required but your answer should clearly explain the purpose and functionality of the map() and reduce() functions in solving this problem. 7 MARKS